Relation of hard and total cross sections to centrality*

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We compare the fractions of the hard and geometric cross sections as a function of impact parameter. For a given definition of central collisions, we calculate the corresponding impact parameter and the fraction of the hard cross section contained within this cut.

Considering only geometry with no nuclear effects, the inclusive production cross section of hard probes increases as

$$\sigma_{\rm AB}^{\rm hard} = \int d^2b \, \sigma_{pp}^{\rm hard} \, T_{\rm AB}(b) \ , \qquad (1)$$

where $T_{\rm AB}(b)$ is the nuclear overlap integral, $T_{\rm AB}(\vec{b}) = \int d^2s \, T_{\rm A}(\vec{s}) \, T_{\rm B}(\vec{b} - \vec{s})$ and $T_{\rm A} = \int dz \rho_{\rm A}(z, \vec{s})$ is the nuclear profile function. Integrating $T_{\rm AB}$ over all impact parameters we find $\int d^2b \, T_{\rm AB}(b) = AB$.

The central fraction $f_{\rm AB}$, equivalent to the fraction of the total hard cross section, is defined as

$$f_{\rm AB} = \frac{2\pi}{AB} \int_0^{b_c} b \, db \, T_{\rm AB}(b) \ , \qquad (2)$$

where b_c is the central impact parameter and $b < b_c$ are central.

Note that $f_{\rm AB}$ is not the fraction of the geometric cross section which includes both hard and soft contributions. The geometric cross section in central collisions is found by integrating the interaction probability over impact parameter up to b_c,

$$\sigma_{\rm geo}(b_c) = 2\pi \int_0^{b_c} b \, db \, [1 - \exp(-T_{\rm AB}\sigma_{NN})] \ , \qquad (3)$$

where σ_{NN} is the nucleon-nucleon inelastic cross section. The fraction of the geometric cross section is

$$f_{\rm geo} = \frac{\sigma_{\rm geo}(b_c)}{\sigma_{\rm geo}} \qquad (4)$$

where $\sigma_{\rm geo} = \sigma_{\rm geo}(b_c \to \infty)$. In central collisions, where $T_{\rm AB}$ is large, $\sigma_{\rm geo}(b_c) \propto b_c^2$. However, in peripheral collisions where the nuclear overlap becomes small, $\sigma_{\rm geo}(b_c)$ deviates from the trivial b_c^2 scaling.

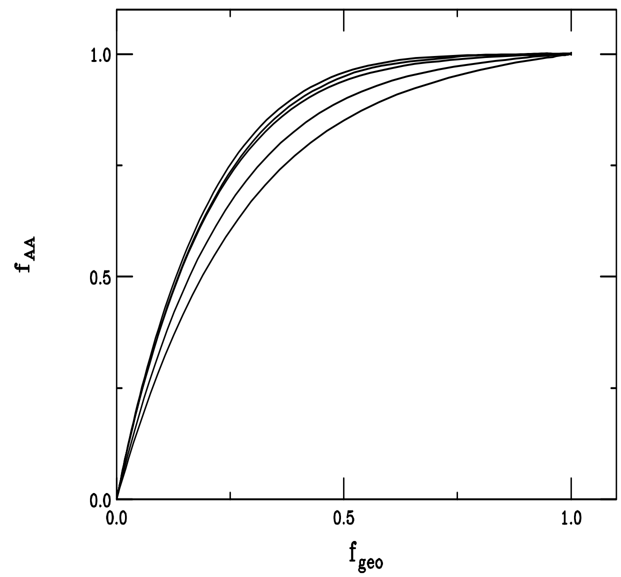

Figure 1: The fraction of the hard cross section as a function of the total geometrical cross section for symmetric systems. From left to right, the curves are 197+197, 110+110, 63+63, 27+27, and 16+16.

Figure 1, shows the ratio of $f_{\rm AB}$ relative to the geometric ratio. The hard fraction grows more slowly relative to the geometric fraction in smaller systems, 16+16 and 27+27, but otherwise the results are similar.

The most appropriate way to obtain the number of hard probes produced in a central collision is to calculate b_c from the geometric cross section and then, with this b_c, calculate $f_{\rm AB}$ with Eq. (2).

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